

- 1 -

METHOD AND APPARATUS FOR MANUFACTURING A PNEUMATIC TYRE  
FOR VEHICLE WHEELS

D e s c r i p t i o n

5

The present invention relates to a method of manufacturing tyres for vehicle wheels.

10 Tyres for vehicle wheels essentially comprise a carcass structure made up of one or more carcass plies that, in the most classic embodiments, have the respective inner circumferential edges turned up around annular inserts usually called "bead cores" and being part of annular reinforcing structures located at axially opposite  
15 positions in the regions usually identified as tyre "beads".

At a radially external position to the carcass ply or plies a belt structure is applied which comprises one  
20 or more belt layers radially superposed in succession. Radially superposed on the belt structure is a tread band of elastomer material. The outer sides of the carcass structure are also covered with respective sidewalls, also made of elastomer material.

25

It is to be pointed out that, to the aims of the present specification, by the term "elastomer material" it is intended a composition comprising at least one elastomer polymer and at least one reinforcing filler.  
30 Preferably, this composition further comprises additives such as cross-linking and/or plasticizing agents, for example. By virtue of the presence of the cross-linking agents, this material can be cross-linked through heating so as to form the final manufactured  
35 article.

- 2 -

Usually the tyre beads, and in particular the annular reinforcing structures integrated therewith, are structured and shaped in a manner suitable for matching with the respective circumferential seats arranged on a rim with which the tyre must be associated, to ensure a steady connection between these two wheel components.

In more detail, coupling between each bead and the corresponding circumferential seat in the rim is of such a nature that the bead is constantly pushed, by effect of the tyre inflating pressure, against an abutment shoulder defining the axially external edge of the rim. At least in tubeless tyres, i.e. tyres devoid of an air tube, each circumferential seat for tyre engagement has a frustoconical surface, hereinafter referred to as "rim flange", having an extension converging towards the rotation axis on moving close to the equatorial plane of the tyre. Each bead, axially pushed away from the equatorial plane by effect of the inflating pressure, acts in axial thrust relationship against the respective rim flange so as to ensure a perfect tightness to the air contained in the tyre.

Recently, rims of new conception for vehicle wheels have been proposed in which the tyre bead engagement seats are of a substantially frustoconical V-shaped conformation having an extension on the whole converging towards the rotation axis away from the equatorial plane.

A method of building tyres that is widely used in the art is commonly known as a "two-stage process". In more detail, tyre manufacture first involves that one or more carcass plies are laid down on a first drum usually identified as "building drum" or "first-stage

- 3 -

drum", to form a cylindrical sleeve. The annular reinforcing inserts to the beads are fitted on opposite end flaps of the carcass ply or plies, that are then turned up around the annular inserts themselves so as to enclose them in a sort of loop.

The carcass sleeve thus built is then transferred to a second drum, a so-called "shaping drum" or "second-stage drum" on which strips of elastomer material adapted to constitute the tyre sidewalls may have been already positioned.

Then shaping of the carcass into a toroidal configuration is carried out so as to couple it with an outer sleeve or crown sleeve (generally prepared separately), located at a centred position with respect to the carcass sleeve, comprising a belt structure and a tread band radially superposed thereon.

After the carcass structure has been shaped, appropriate expandable portions of the shaping drum consisting of lever systems or inflatable bags for example, give rise to an overturning action of said strips of elastomer material to apply said strips against the side surfaces of the carcass structure.

In a unistage process, all the above mentioned previous steps, i.e. building and shaping, take place on a single drum. In this case, often associated with this drum are auxiliary devices including transfer systems for example, for pre-assembling and transferring some semi-finished products (belt structure and tread band, for example) onto the drum itself.

US Patent No. 4,214,940 discloses a turning-up device

for a tyre building drum. The turning-up device comprises an arched support having at least three conical fin elements mounted thereon. Said elements are positioned progressively closer to an axial central  
5 line of the building drum in a rotation direction of the drum itself. A presser roller is rotatably mounted on the support at a position between said conical elements. The support is pivotally mounted on a pivot drive for rotation around an axis disposed at right  
10 angles with respect to the axial central line of the building drum. Pivot drive means is mounted on parallel guide means for movement in a direction parallel to the axial central line of the building drum.

15 US Patent 6,250,356 discloses a first-stage drum and a building method for making tyres. Said drum involves a body mounted on a central shaft and having a receiving surface for the semi-finished products to be assembled, the ends of which, of different diameters, hold  
20 retractable means capable of covering the end of the receiving surface of smaller diameter, and means to expand the drum towards two different expansion positions. The building method contemplates: using a first surface having ends of different diameter;  
25 moving towards said first surface, a second surface of almost the same diameter as the end of greater diameter for the purpose of covering the end of smaller diameter of the first surface and creating a generally cylindrical overall receiving surface; laying down a  
30 carcass reinforcement onto said overall surface; laying down a ring-shaped element made of rubber or metal onto each of the carcass reinforcement ends, respectively; contracting the second surface and expanding the first surface; turning upwardly each end of the carcass  
35 portion to be turned up around the corresponding ring-

shaped element, respectively.

The Applicant has therefore perceived that, if one wishes to build, by means of a first-stage drum, a  
5 tyre having the carcass ply turned up around an annular element, preferably of elastomer material (which tyre is particularly adapted for coupling with the previously illustrated rims of new conception) and a bead core placed on the completed turned-up portion of  
10 said ply, since arrangement of a ply turned up on filling elements is not provided, traditional turning-up devices lose their effectiveness. In fact, in this case it is no longer possible to exert high thrusts on the ply to avoid unevennesses in the turned-up portion  
15 because there is no more any rigid annular element that, being locked on the drum, exerts a retaining action on the ply avoiding every movement thereof.

Consequently, in the Applicant's perception, it is  
20 suitable to search for devices possibly external to the drum body, that are capable of turning up the carcass ply in the manner depicted above. More specifically, said devices, in order to accomplish their task, in the Applicant's opinion, keep the edges of said ply  
25 separated from the other semi-finished products disposed on said first-stage drum to enable turning up of the ply itself around said annular element. In addition, the turning up devices carry out turning up of said ply edges also without the aid of a rigid  
30 retaining element such as a bead core.

The Applicant has found that by using an element external to the building drum for separating at least one carcass ply portion from the other semi-finished  
35 products placed on said drum during building of the

---

tyre, the flaps of said ply are turned up around a semi-finished product (preferably of elastomer material) by the only retaining reaction due to said semi-finished product and to adhesion of said ply to  
5 the region not concerned with the turned-up portion and therefore in contact with the other semi-finished products.

In addition, since said element is external to the  
10 shaping drum, it brilliantly solves the above expounded drawbacks avoiding the requirement of making specific first-stage drums, as provided in the previously illustrated solution disclosed in US 6,250,356 for example, and enabling the drums already in use to be  
15 modified with great ease.

In a first aspect the invention relates to a method of manufacturing a tyre for vehicle wheels, said tyre comprising a carcass structure having at least one  
20 carcass ply operatively associated with a pair of annular reinforcing structures suitable for matching with a mounting rim, each annular reinforcing structure comprising at least one bead core and one annular element, said at least one carcass ply being turned up  
25 at least on one of said annular elements, said method comprising the steps of: feeding at least one semi-finished product onto a first-stage drum, placing at least one separating element to a position radially external to said at least one semi-finished product,  
30 feeding said at least one carcass ply onto said first-stage drum at a radially external position with respect to said at least one separating element, placing said annular elements to a position radially external to said carcass ply, turning up said carcass ply around  
35 said annular elements, removing said at least one

- 7 -

separating element, applying said bead cores, transferring said carcass structure to a second-stage drum, applying a belt structure to said carcass structure at a radially external position, applying a  
5 tread band to said belt structure at a radially external position, shaping said tyre into a toroidal conformation.

In a further aspect the invention relates to a first-  
10 stage drum for building a tyre for vehicle wheels, said tyre comprising a carcass structure having at least one carcass ply operatively associated with a pair of annular reinforcing structures suitable for matching with a mounting rim, each annular reinforcing structure  
15 comprising at least one bead core and one annular element, said at least one carcass ply being turned up at least on one of said annular elements; said first-stage drum comprising at least: one central portion operatively associated with two side portions, at least  
20 one transport device for said bead cores, at least one pressure device adapted to consolidate the different semi-finished products with each other, at least one turning-up device for said carcass ply and a device adapted to radially modify the surface of said drum,  
25 wherein said turning-up device comprises at least one tubular separating element open at least at one end, externally associated with said first-stage drum.

Further features and advantages of the invention will  
30 become more apparent from the detailed description of some preferred but not exclusive embodiments of a method and an apparatus for manufacturing a tyre for vehicle wheels in accordance with the present invention.

35

Such a description will be set out hereinafter with reference to the accompanying drawings, given by way of non-limiting example, in which:

- Fig. 1 is a partial diagrammatic view in right section showing a tyre for vehicle wheels made in accordance with the invention;
  - Figs. 2 to 13 are diagrammatic views in right section of the apparatus of the invention during some steps of the method in reference in accordance with a first embodiment;
  - Figs. 14 to 17 are diagrammatic views in right section of the apparatus of the invention during some steps of the method in reference in accordance with a further embodiment;
  - Fig. 18 is a partial view in vertical section of the apparatus of the invention;
  - Fig. 19 is an overall view in vertical section of the apparatus in reference.
- As shown in Fig. 1, tyre 1 built by the method in accordance with the invention comprises a carcass structure having at least one carcass ply 2, one annular reinforcing structure 3 for each bead and one pair of fillers 4 for said beads, said carcass structure being associated with at least one pair of sidewalls 5, one tread band 6 at a radially external position thereto, and one belt structure 7 placed between said carcass structure and tread band. Advantageously, for each annular reinforcing structure 3, provision is made for an annular bead core 8 (made of steel for example, following known methodologies) and an annular element 9, the cross-section outline of which substantially has a wedge-shaped conformation the base side of which is essentially parallel to the flange of a rim on which said tyre 1 is mounted. Said



- 9 -

wedge at an axially external position thereof is adjacent to said bead core and its tapering end belonging to said base side is at a radially internal position with respect to said bead core 8. Said carcass  
5 ply 2 is preferably partly wound around said bead cores 8 whereas it is completely wound around said annular elements or wedges 9, ultimately presenting each end flap 10 in contact with the radially internal portion of the corresponding bead core 8. In accordance with a  
10 preferred embodiment, said annular wedges 9 are made of an elastomer material of a SHORE A hardness included between 80 and 110 degrees, preferably of 95 degrees.

The apparatus of the invention (Figs. 18-19) to build  
15 said tyre 1 substantially consists of a first-stage drum 20 comprising a central portion 32 provided with a rigid cover 33 (at all events adapted to be dismantled for replacement with covers of different widths) and two axially opposite side portions 34 each provided  
20 with a radially expandable auxiliary bladder-like membrane.

The rigid cover 33 telescopically covers the axially internal ends of the side portions 34 of drum 20, so  
25 that in the starting building step a continuous cylindrical surface is created over the whole drum for deposition of the semi-finished products thereon.

Said drum 20 further comprises devices 24 adapted to  
30 carry a pair of said bead cores 8 therearound until a predetermined mutual distance is reached to enable the building steps better described in the following to be carried out. Movement required for transport is obtained by a preferably electric motor 40 for example,  
35 operatively associated with a driving screw 41 in turn

---

- 10 -

connected to said devices 24.

The concerned drum 20 further comprises a first pressure device that through a presser roller 21 (Fig. 4) acting on the annular wedges 9 carries out, as better illustrated in the following, consolidation of the adhesion between the carcass ply 2 and the underlying sidewalls 5 at the contact points of same; a second device 22 for loop-shaped turning up of the flaps 10 of said carcass ply around said annular wedges 9; and a third device 23 for outward radial displacement of wedges 9 once they have been surrounded by the carcass ply 2 loops, against the surface of the bead cores 8 supported by said transport devices 24, said third device being internal to the tubular surface of each of said auxiliary bladder-like membranes.

Advantageously, said transport devices 24 for bead cores 8 and said third device 23 for radial expansion are such arranged as to ensure stopping of the inner surface of each bead core 8 on at least one end portion of the turned-up flap of the carcass ply 2 around the corresponding wedge 9.

In a preferred embodiment, the concerned drum is provided with a further pressure device designed to act, as better illustrated in the following, on the flaps 10 of the carcass ply 2 formed around said wedges 9, said device being operatively associated with said second turning-up device 22. Said further pressure device is conveniently in the form of an inflatable bag 25 of annular shape, coaxial with said drum and of bigger diameter than the latter, said bag being expandable during operation of said drum towards the

- 11 -

drum surface.

As an alternative to the solution involving the inflatable bags 25, one or more presser rollers also associated with device 22, can be employed.

Preferably, said second device 22 is provided, close to each sidewall of said drum 20, with at least one tubular element 26 of smaller diameter than or the same diameter as said drum and coaxial therewith, said second device 22 being axially movable in both the drum directions and free to rotate around the drum axis.

The possibility of movement of said device 22 around the drum axis is particularly advantageous because it enables any rotating movement of said drum 20, as better shown in the following, not to alter the integrity of said tubular element 26 while the latter is associated with one or more of the semi-finished products during the tyre building process.

As better described in the following, in order to separate both the flaps 10 of axially external ends of the carcass ply 2, said turning-up device 22 is provided to be divided into two parts or halves each of which is placed at an axially external position on opposite sides with respect to said drum (Fig. 19). Preferably said turning-up device 22 is driven by a motor 42 operatively associated with a drive screw 43 controlling movement of said device.

Optionally, also provided is a radiated-off cord, comprising a plurality of thread-like elements circumferentially disposed around said tubular element 26, which cord when suitably operated carries out

- 12 -

widening or release of the opening end of the tubular element 26 enabling fitting of same on drum 20 without any initial rubbing on the already present semi-finished products.

5

The tubular element is preferably made so as to have features of elasticity in a radial direction and substantial non-elasticity in a transverse direction. In addition, for making said tubular element 26, a  
10 fabric made of anti-adhesive material is preferably employed, said tubular element therefore performing a mechanical isolation, i.e. being a true separating element for the semi-finished products with which it comes into contact.

15

Preferably, but not exclusively, use of said third device 23 for displacement of said wedges 9 in a radially external direction comprises, on each side of the drum, first and second radial-expansion devices, 27  
20 and 28 respectively, that are axially and radially movable with respect to each other by means of appropriate mechanisms. More specifically a piston 35, preferably of the air type, is operatively associated with a lifting wedge 36 in turn connected to said first  
25 radial-expansion devices 27 to operate movement of the latter. The return movement, on stopping of the thrust caused by said piston 35 is preferably carried out by elastic devices such as a spring ring or springs. Movement of said second radial-expansion devices 28 is  
30 controlled by a piston 37, preferably of the air type, operating a lifting wedge 38 in turn associated with said second devices 28. In this case too, elastic devices such as a spring ring or springs are provided for the return movement of said devices 28.

35

The first radial-expansion devices 27 are formed of a plurality of sectors the outermost surface of which, at least when said sectors are at a radially external position, creates a housing seat 29 with a concave surface, whereas said second radial-expansion devices 28 are preferably formed of a plurality of sectors the outermost surface of which terminates with a convex head 30 (Fig. 11). The sectors of said devices 27 and 28 in addition form, in the expanded configuration, a concave outer surface suitable to create the appropriate profile for deposition of fillers 4 and an appropriate axial-retaining action against sliding of bead core 8 and wedges 9 towards the inside of the drum. It will be also appreciated that each radial-expansion device 27 can be made of a rigid material of one piece construction or, in a different embodiment (Fig. 18), it may be formed of two parts, the upper one 27' being preferably made of elastomer material to advantageously mitigate the concave surface of said housing seat 29.

Said radial-expansion devices 27, 28 finally comprise contact surfaces 31 inclined with respect to each other.

As shown in Figs. 2 and 3, the method of the invention at the beginning involves a first step in which while devices 23 are in a contracted configuration, a first semi-finished product is laid down on the radially external surface of said drum 20. Said semi-finished product preferably comprises a liner (i.e. that portion that when the tyre has been completed is at a radially internal position and is responsible for air-tightness in tubeless tyres) and the sidewalls. Optionally each sidewall may consist of two parts.

Once said semi-finished product is laid down on the drum and possibly maintained in place by the action of the vacuum applied from the inside of the drum, said turning-up device 22 in its halves is moved by said motor 42 in an axially internal direction relative to drum 20, preferably by a reciprocating motion of the to-and-fro type that enables the tubular elements 26 to be positioned so as to be wrapped around the above mentioned semi-finished product and leave the central region of the drum completely clear for deposition of the carcass ply 2 thereon. Positioning of the tubular elements is carried out depending on the point at which subsequently folding back of the carcass ply 2 onto the annular wedges 9 is wished to begin. Advantageously, since said tubular element 26 is made of an anti-adhesive textile material, the carcass ply 2 laid down after said first semi-finished product cannot adhere over the whole length thereof, to the pieces already present on the drum, but keeps mostly separated therefrom. As previously illustrated, in order to separate both the axially external end flaps 10 of the carcass ply 2, said turning-up device 22 is divided into two parts or halves: each of them therefore performs a to and fro movement which may also be non contemporaneous to cause partial wrapping of said tubular elements 26 around said drum.

As shown in Fig. 4, in a subsequent step of the concerned method, other semi-finished products are laid down on said drum at a radially external position, more specifically said carcass ply 2 and said annular wedges 9, close to each of said flaps 10 of the carcass ply 2. This operation can be carried out, as previously depicted, with the tubular elements 26 positioned on

- 15 -

the drum due to freedom of rotation of said elements around the axis of the drum itself. In addition, optionally, use of the presser roller 21 may be provided to promote and consolidate adhesion between  
5 ply 2 and sidewalls 5 at the contact points of same, i.e. where said sidewalls are not covered with said tubular elements 26.

Subsequently, as shown in Fig. 5, a further forward  
10 movement (i.e. in an axially internal direction) of said turning-up device 22 enables one portion of each tubular element 26 to raise the respective flaps 10 starting wrapping of each of them around the corresponding annular wedge 9.

15

In a further step (Fig. 6), said transport devices 24 driven by said motor 40, carry out axial positioning of each bead core 8 by substantially placing each of them at a radially external position relative to each wedge  
20 9 and at a position substantially adjacent and axially external to the respective flap 10 partly turned up around said wedge 9.

25 Subsequently (Fig. 7) each tubular element 26 is slipped off by moving each half of device 22 inwardly in an axial direction, until it comes close to the transverse symmetry axis of said drum, which enables disengagement of each flap 10 from said device 22.

30

As shown in Fig. 8, each bead core - transport device 24 places said bead cores at a position radially external to each annular wedge 9, each flap 10 of said carcass ply 2 being interposed between said wedge 9 and  
35 bead core 8.

- 16 -

In a further step of the concerned method, as shown in Fig. 9, devices 23 are operated by pushing said wedges 9 and the underlying semi-finished products to a radially external direction, while each bead core 8 is kept stationary at a radial position by said transport devices 24.

Alternatively, said devices 24 may also be positioned slightly external to the final axial position of bead core 8 so that during the action of devices 23 in a radially external direction and the early disengagement of bead cores 8 from devices 24, the bead cores should slightly rub on flaps 10 of the carcass ply 2 carrying out a compressive and consolidating action of the loop before said bead cores occupy their final seat.

In the subsequent step, as shown in Fig. 10, as the devices 23 continue their action, a particular conformation of the semi-finished products hitherto laid down for tyre building is obtained. In detail, bead cores and wedges will substantially have the same radial position with each wedge placed at an axially external position with respect to the bead core, and each flap 10 will be completely wrapped around said wedge 9 and at a position radially internal to said bead core 8.

Fig. 11 shows a further step in which device 22 in its halves is brought back to a position axially external to said drum.

In the subsequent step illustrated in Fig. 12, with the aid of said devices 23, said fillers 4 are added to the tyre being built and in the above configuration.



Building of the tyre then goes on as shown in Fig. 13, acting by means of axial thrusts from said devices 23 and inflation of the auxiliary membranes of the side  
5 drum parts.

Once the whole carcass structure has been built, it is sent to a second-stage drum (not shown) on which the subsequent steps involving deposition of said belt  
10 structure 7 and tread band 6, as well as the final toroidal conformation of the green tyre ready for vulcanisation are substantially carried out as in known shaping processes, in accordance with the so-called  
"overlying sidewall" or "underlying sidewall"  
15 techniques following the specifications for the tyre to be obtained (which steps are substantially known in the art and therefore not illustrated).

In an important alternative embodiment of the method in reference, the step shown in Fig. 14 is similar to that  
20 shown in Fig. 5, but in the last-mentioned case device 22 in each half is also provided, in addition to the tubular element 26, with an inflatable bag 25 which is brought to a position radially external to each annular  
25 wedge 9 and each flap 10.

In the subsequent step shown in Fig. 15, inflation of said bag 25 causes said flap 10 to be wrapped around said wedge 9, substantially carrying out and completing  
30 turning-up of each flap 10.

The subsequent step illustrated in Fig. 16 shows moving apart of the device 22 halves in an axially external direction, which causes the tubular elements 26 to slip  
35 off and the inflatable bags 25 to move away in a

deflated condition.

The further step of this alternative embodiment of the method in reference (Fig. 17) contemplates positioning  
5 of said bead cores 8 by said transport devices 24 to a position radially external to said flaps 10 wrapped up around said wedges 9.

Subsequently, the same configurations are determined as  
10 already discussed above for the steps of the preceding alternative embodiment of the method in reference depicted in Figs. 10, 12 and 13; finally, the same remarks as above can be made for final assembling of the belt structure and tread band and for the toroidal  
15 conformation of said tyre.

---